Interview with Dr. Raj Khosla, Colorado State University

Prof. Raj Khosla is a Robert E. Gardner Professor of Precision Agriculture at the Colorado State University. He is the Founder and Past-President of the International Society of Precision Agriculture.

You are one of the most influential researchers in Precision Agriculture and you have followed its evolution since the very beginning. What has been the evolution and the lessons learned in crop and soil sensing since you started?

Yes. Precision Ag has come a long way since its inception. I would say in the last couple of decades since precision ag has been around, initially a huge amount of time, money and resources were spent on quantifying spatial variability primarily in soils and then later on in crops as well. In the last decade, there is a whole suite of sensors that became commercially available, and we have made significant progress in terms of characterizing soils using soil electrical conductivity, likewise characterizing variability in crop canopy using a suite of reflectance-based crop sensors. However, I think that we still have a long way to go. Let me elaborate. For example, if you look at any reflectance sensor and the associated vegetative index, it primarily gives you a flavor of biotic or abiotic stress, it doesn't really tell you which particular stress or the cause of that stress. For example, we use NDVI, a lot of times we use that to make nitrogen decisions, when, in reality NDVI only tells you that there is an anomaly, which we intelligently assume (using algorithms) that it is related to nitrogen but we don't necessarily know that nitrogen deficiency is really the cause, because it could be iron chlorosis, it could be insect, pest infestation that made the plant look pale or many other factors that could result in a low NDVI value. So I think what we have in place right now in terms of sensing, I would classify that as the 1st generation sensors. As we go forward, hopefully we'll have sensors that would enable accurate classification of the problem that we detect in the fields.

In the last few years many crop vigour sensors and sensing techniques have appeared in the market but there seems not to be an accepted standard in vegetation indices, spectral bands, methodology, etc. How do you think this is affecting the application of Precision Agriculture solutions, the inter-season comparison and the decision making?

I think you bring up a very good point. The reason that farmers are reacting slow to adopt these new ways of sensor based recommendations is because, as I mentioned earlier, we don't precisely know what is causing the plant stress. Is it truly driven by nitrogen deficiency or there's a whole suite of crop response that can be captured by vegetative indices currently available to farmers. I would say, NDVI has been one of the most widely used vegetative index. More recently, as research dollars are being invested into this space, we are developing newer indices such as red edge based vegetative indices that are providing us with a better spectral response to aberrations. And so, until we have the sensing capability that can accurately inform us about the prevailing deficiencies in crop, we're going to tweak and try and continue to learn this process until we get there.

In many devices, such as soil sensors, the sensor output may give an idea of the signal spatial variability. However, the sensor signal is usually related to many soil properties and a single/simple diagnosis cannot be derived. Do you think this is still useful?

You're exactly right. The sensor signal is a culmination of a number of properties that are captured collectively in the sensor response. And one may argue that it has limited value because it does not pinpoint the exact cause. Having said that, one of the abilities of existing sensors is the ability to map large swaths of land in relatively short period of time without having to take very many destructive soil samples, without necessarily spending too much money, labour and time. And so what it does, it allows you to capture patterns of spatial variability out in the field. And I think there is tremendous value in knowing where the changes are in the soil because one can then go out in the field and can do some ground truthing in figuring out what is the cause that you see a change as you go from one part of the field to the next part. So yes, there is value in the current sensing systems.

How do you think sensing techniques will evolve in the coming years? What will make farmers around the world use them?

You are asking me a two pronged question. One related to research, the other related to adoption of a particular technique or technology by farmers. Precision agriculture is only about 20-25 years old but agriculture is more than 1,000 years old so we need to keep that in mind. I know we are using information technologies these days to help advance our agriculture, and such IT technologies advance quickly. But I think we need to put some realistic expectation in terms of what these new technologies can do for us. Until we are trying to figure out and improve our existing understanding of soils and crops based on what is commercially available in the sensing world, and develop scientifically proven and reproducible techniques and technologies, I think it would be unfair for us to expect that farmers are going to abandon their generations of time tested way of doing agriculture and jump on board and say we are now going to use sensing based agricultural decisions. I think it's an issue where we are building something and trying to use it at the same time. So there will be a learning curve, there will be growing pains. Slowly and surely we are making progress, and farmers are picking and choosing aspects of sensing, aspects of precision agriculture that currently fit into their operations. I think this will be a long journey before we actually get there, and I think we will!